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Apparatus and Method for Projecting Images and/or Processing Materials

Technical Field

The present invention relates to an apparatus for projecting images and/or processing materials, the apparatus having a deflection device for variable deflection of a beam of light emanating from a light source onto a projection area or a processing area, a modulation device for modulating the intensity of the light beam and a control unit which is connected to the modulation device and by means of which the modulation device can be triggered to modulate the intensity of the light beam according to input data. Furthermore, the present invention relates to a method for projecting images and/or processing materials, in said method a light beam is conveyed by means of a deflection device via an image region or a processing region of a projection area or a processing area and is simultaneously modulated in order to obtain image projection or material processing corresponding to input data.

When employing an apparatus of the mentioned sort, in order to project images, the image region of the projection area is usually scanned by a light beam with a constant line frequency and column frequency while simultaneously the intensity of the light beam is modulated according to input data to represent an image or a sequence of images. The image can be used for information representation or in the case of correspondingly high light power intensity also for lettering or material processing. In the simplest case, the representation may be a representation of a one-dimensional figure with deflection in only one direction. Generally, however, the light beam is deflected in two directions to create a flat image.

In employing a generic apparatus for material processing, the deflection device can also be triggered according to input data to guide the light beam along a specific path over the processing region of the processing area predefined by the processing parameters while the light intensity is simultaneously modulated accordingly.

Prior Art

Generic apparatuses are realized as microscanners or as precision scanners that can be operated resonantly as well as quasi-statically. For example, WO 03/032046 A1 describes a projection apparatus that is used to represent images, patterns, lettering or symbols or to illuminate a photosensitive material. This projection apparatus comprises a deflection device to deflect a light beam about a first deflection axis with a first deflection frequency and about a second deflection axis with a second deflection frequency to move the light beam over the image area. The intensity of the light beam is modulated by means of a modulation device according to the to-be-projected image. In an embodiment of this printed publication, the deflection device has a unit to fade out the light source as soon as the light beam is deflected by the deflection device into a peripheral region of the projection area. In this connection, it is explained that this can be achieved by, for example, switching off the light source in this peripheral region and that serves to homogenize image dot density during projection.

When using powerful light sources, such as for instance lasers, to generate very great light power intensity, as required in particular in material processing, the mobile deflection mirror of the deflection device becomes hot due to finite absorption, which can lead to thermally induced curvature of the mirror and/or, for example in the case of spring-suspended microscanner mirrors, to altering the

spring constants. The curvature of the mirror leads to defocusing, the alteration of the spring constants, in particular in the case of resonantly operated microscanners, to the alteration of the resonance amplitude or to desynchronization in relation to the image data flow. In this case, the mean intensity received by the mirror is generally not temporally constant, because the mean intensity of the light beam changes according to the to-be-represented image or the to-be-conducted material processing. Therefore, even after a warming-up phase of the apparatus, no constant mirror temperature is attained.

In order to prevent these problems, large mirrors can principally be cooled. This cooling , however, is complicated and expensive and, especially in the case of microscanner mirrors, cannot be technically realized in a practical manner, because cooling has to occur with very good thermal contact to the mirror. Therefore, for microscanner mirrors there is no known technical solution to prevent the aforementioned problems.

The object of the present invention is to provide an apparatus and a method for image projecting and/or material processing, in which fluctuations in temperature on the beam deflection elements of the deflection device during projecting and/or processing are considerably reduced.

Summary of the Invention

The object of the present invention is solved with the apparatus according to claim 1 and the method according to claim 11. Advantageous embodiments of the apparatus and the method are the subject matter of the subordinate claims or can be drawn from the following description and preferred embodiments.

The present apparatus for projecting images and/or processing materials is provided with a deflection device to variably deflect a light beam emanating from the light beam onto a projection area or a processing area, a modulation device to modulate an intensity of the light beam and a control unit which is connected to the modulation device and by means of which the modulation device can be triggered to modulate the intensity of the light beam according to input data. The apparatus is distinguished by a shading element being disposed between the deflection device and the projection area or the processing area, with said shading the light beam can be faded out for one or a multiplicity of time segments within a multiplicity of time intervals, into which the total duration of the projection and/or the processing is subdividable, and the control unit includes a control program which regulates the modulation device during these time segments in such a manner that an at least approximately constant mean light intensity of the light beam is yielded in the time intervals.

In the corresponding method, the light beam is conveyed by means of the deflection device via an image region or processing region of the projection area or the processing area and is simultaneously modulated in intensity according to the input data to obtain image representation or material processing according to the input data. In the method, the total duration of the projection and/or the processing is subdivided into a multiplicity time intervals. The light beam is faded out between the deflection device and the projection area or the processing area for one or a multiplicity of time segments within each time interval and adjusted in intensity in these time segments in such a manner that an at least approximately constant mean intensity of the light beam is achieved in all the time intervals.

The temporary fading out of the light beam, which occurs solely by means of the shading element or by means of the deflection device in conjunction with the shading element, and the corresponding regulation of the light intensity permit achieving an approximately constant thermal input in the deflection element and thus by selecting correspondingly short time intervals, obtaining a temporally constant temperature of this deflection element during image projection or material processing. Processing images, respectively processing materials, occurs with the intensity course of the light beam according to the input data, the fading out pauses, of course, being taken into consideration. However, the temporary fading out permits adjusting the light intensity within the time segments, in which the light beam is conveyed in the same manner via the deflection element, in such a manner that the same mean light intensity of the light beam is yielded for each predefined time interval without influencing image projection or material processing. Differences in the course of the intensity of the light beam for projection images or processing materials from time interval to time interval can be compensated in a simple manner.

The differences in the course of intensity are known from the input data, the fading out time segments from the placement of the shading element and the deflection parameters of the deflection device.

Fading out the light beam can be achieved, for example, by means of an optical shutter which is placed in the beam path between the deflection device and the projection area and which interrupts the light beam at certain time points, for example periodically. In the preferred embodiment of the present apparatus and the present method, however, a shading element is provided which delimits the image region

or processing region at least on one side by means of a margin, the light beam being repeatedly conveyed by the deflection device onto the margin during projection and/or processing to achieve the fading out. The region (scan region) covered by the deflection device is thus larger than the image area, respectively processing area, delimited by the shading element.

The present apparatus and the method functions are explained again in the following in an exemplary manner using the image projection of a sequence of images. Execution can, of course, be readily applied to the time intervals in material processing. The time intervals selected in the present example of image projection correspond to the duration of the representation of an image. They may, of course, be longer or shorter than the representation time of an image and are selected primarily according to the thermal propagation on the deflection element to achieve minimal or no temperature fluctuations in the deflection element. The duration of the time intervals may also vary during projection or processing.

If the light beam requires the time t for the representation of the whole image, this time interval is composed of the time t_1 for the part being imaged and the time t_2 for the part faded out. Given is: $t = t_1 + t_2$. If in the case of the image n for t_1, the mean intensity $I_{mean,1,n}$ is used for imaging, with generally $I_{mean,1,n} \neq I_{mean,2,k}$ with $k \neq n$, during t_2 the intensity $I_{mean,2,n}$ is adjusted in such a manner that in each interval

$$I_{mean,1} \times t_1 + I_{mean,2} \times t_2 = \text{constant}. \quad (1)$$

In this manner, always the same mean intensity is conveyed via the mirror, with the part of the light beam reaching

imaging being variable as desired with suited selection of the parameters.

The present apparatus and the corresponding method can be utilized with any deflection devices, light sources and modulation devices.

Thus, microscanners, precision scanners, vector scanners, resonantly operated scanners or quasi-static scanners can be used in the state-of-the-art manner as the deflection device. The deflection device preferably comprises uniaxially or biaxially movable mirrors. However, two uniaxially movable mirrors connected in series whose axes of motion are disposed perpendicular to each other can achieve two-dimensional beam deflection in the same manner as if using one biaxially movable mirror. The present apparatus and the corresponding method can also be realized by means of deflection devices that deflect only in one dimension.

The light source may be a component of the apparatus or provided separately, with the light beam in that case being coupled in accordingly. In addition to the frequently used lasers and light diodes, general thermal light sources or gas discharge lamps can be employed as light sources. The apparatus can, of course, also be operated using pulsed light radiation.

The modulation device can either regulate the output of the light source directly or be disposed in the light beam as a separate modulator. In prior-art projection apparatuses, contrast is achieved by switching the light beam on and off, respectively by means of gray-step modulation. This technique can also be employed in the present apparatus and the present method.

If need be, the present apparatus, of course, also includes focusing optics with which the light beam is usually focused onto the projection area or the processing area as required in many applications.

Brief Description of the Drawings

The present apparatus and the corresponding method are made more apparent in the following using preferred embodiments with reference to the accompanying drawings.

Fig. 1 shows an example of a preferred embodiment of the present apparatus for projecting images;

Fig. 2 shows another view of a region of the example of figure 1; and

Fig. 3 shows examples of shading elements as utilized in the present apparatus and present method.

Ways to Carry Out the Invention

Fig. 1 shows schematically an example of a possible embodiment of the present apparatus. For clarity, the figure is not drawn to scale and shows an apparatus for monochrome representation of an image. In this example, the apparatus is composed of a laser 1 as the light source, the deflection device 3, a diaphragm 6 as shading element between the deflection device 3 and the projection area 7, the modulation device 4 and the control unit 5. The diaphragm 6 should, of course, be placed at a correspondingly large distance from the projection area 7, i.e. as close as possible to the deflection device 3 to prevent scattering and diffraction effects. The deflection device 3 comprises a biaxially movable micromirror 9 as the deflection element. The image data are conveyed to the control unit 5 connected to the modulation device 4 and are processed there according to, in this case, a fixed ratio

of time to the excursion angle of the deflection device 3. The control unit 5 then causes modulation device 3 to regulate the intensity of the laser beam 1 emitting thus a laser beam 2 modulated accordingly in intensity. The laser beam 2 is moved by the deflection device 3, in particular by the biaxially movable suspended mirror 9 over the projection area 7, the diaphragm cutting out the peripheral region of the projection area 7 in such a manner that a limited image region 8 is yielded through the diaphragm aperture for representation of the image 10. Thus the deflection device 3 scans a larger solid angle region with the laser beam 2 than is visible on the projection area. The modulation of the laser beam 2 for representation of image 10 occurs only within the image region 8. Beyond image region 8, the laser beam impinges on the diaphragm 6 in such a manner that during this time segment it does not contribute to representation of the image. In order to keep the mean light intensity conveyed via the mirror 9 constant from image to image, according to equation (1) of the preceding section, light intensity is adjusted accordingly during this time segment by the modulation device 4. In this manner, an approximately constant temperature of the mirror 9 is ensured during total projection. The length of the time intervals selected for the constant mean intensity is dependent on the thermal propagation on the deflection element, in this case the mirror 9. Thus, in the case of deflection elements with relatively great thermal capacity, for example, a multiplicity of images can be averaged, i.e. the time intervals are selected correspondingly large for the averaging. On the other hand, in the case of relatively small thermal capacity of the deflection element, it can be advantageous, for example in the case of scanning deflection to even average line for line.

Fig. 2 shows the same setup without the modulation device, the control unit or the laser. In this case, however, in a view in which projection occurs away from the observer.

In addition to a diaphragm as a shading element, other shading elements, of which some are shown as examples in fig. 3, can be used in the present apparatus and the present method. From left to right, fig. 3 depicts first the prior-art diaphragm, then an element which delimits the image region only on one side, next an element which delimits the image region on two sides, for example a simple metal plate, and finally an optical shutter which rotates with a constant frequency, indicated by the arrow, in such a manner that it periodically interrupts the light beam.

List of References

1	laser
2	laser beam
3	deflection device
4	modulation device
5	control unit
6	diaphragm
7	projection area or processing area
8	image region of processing region
9	biaxially movable micromirror
10	image